

## SL Acid Base Review (2011 Exam)

Name.....

1. Which equation represents an acid-base reaction according to the Lewis theory **but** not the Brønsted-Lowry theory?
- A.  $\text{NH}_3 + \text{HCl} \rightleftharpoons \text{NH}_4\text{Cl}$
- B.  $2\text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{O}^+ + \text{OH}^-$
- C.  $\text{NaOH} + \text{HCl} \rightleftharpoons \text{NaCl} + \text{H}_2\text{O}$
- D.  $\text{CrCl}_3 + 6\text{NH}_3 \rightleftharpoons [\text{Cr}(\text{NH}_3)_6]^{3+} + 3\text{Cl}^-$
2. Which **one** of the following species can act as both a Brønsted-Lowry acid and base in aqueous solution?
- A.  $\text{CH}_3\text{COOH}$
- B.  $\text{NO}_3^-$
- C.  $\text{H}_2\text{PO}_4^-$
- D.  $\text{OH}^-$
3. Lime is added to a lake to neutralize the effects of acid rain. The pH value of the lake water rises from 4 to 7. What is the change in concentration of  $\text{H}^+$  ions in the lake water?
- A. An increase by a factor of 3
- B. An increase by a factor of 1000
- C. A decrease by a factor of 3
- D. A decrease by a factor of 1000
4. In which reaction is  $\text{H}_2\text{PO}_4^-$ (aq) acting as a Brønsted-Lowry base?
- A.  $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{NH}_3(\text{aq}) \rightarrow \text{HPO}_4^{2-}(\text{aq}) + \text{NH}_4^+(\text{aq})$
- B.  $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{HPO}_4^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- C.  $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{C}_2\text{H}_5\text{NH}_2(\text{aq}) \rightarrow \text{HPO}_4^{2-}(\text{aq}) + \text{C}_2\text{H}_5\text{NH}_3^+(\text{aq})$
- D.  $\text{H}_2\text{PO}_4^-(\text{aq}) + \text{CH}_3\text{COOH}(\text{aq}) \rightarrow \text{H}_3\text{PO}_4(\text{aq}) + \text{CH}_3\text{COO}^-(\text{aq})$
5. An aqueous solution of which of the following reacts with magnesium metal?
- A. Ammonia
- B. Hydrogen chloride
- C. Potassium hydroxide
- D. Sodium hydrogencarbonate
6. Which substance can be dissolved in water to give a  $0.1 \text{ mol dm}^{-3}$  solution with a high pH and a high electrical conductivity?
- A. HCl
- B. NaCl
- C.  $\text{NH}_3$
- D. NaOH
7. Which is **not** a strong acid?
- A. Nitric acid
- B. Sulfuric acid
- C. Carbonic acid
- D. Hydrochloric acid
8. Which of the following is/are formed when a metal oxide reacts with a dilute acid?
- I. A metal salt
- II. Water
- III. Hydrogen gas
- A. I only
- B. I and II only
- C. II and III only
- D. I, II and III

9. Which equation represents an acid-base reaction according to the Lewis theory **but not** according to the Brønsted-Lowry theory?
- A.  $\text{CO}_3^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$
- B.  $\text{Cu}^{2+}(\text{aq}) + 4\text{NH}_3(\text{aq}) \rightarrow \text{Cu}(\text{NH}_3)_4^{2+}(\text{aq})$
- C.  $\text{BaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$
- D.  $\text{NH}_3(\text{g}) + \text{HCl}(\text{g}) \rightarrow \text{NH}_4\text{Cl}(\text{s})$
10. Which is a Brønsted-Lowry acid-base pair?
- A.  $\text{H}_2\text{O}$  and  $\text{O}^{2-}$
- B.  $\text{CH}_3\text{COOH}$  and  $\text{CH}_3\text{COO}^-$
- C.  $\text{NH}_4^+$  and  $\text{NH}_2^-$
- D.  $\text{H}_2\text{SO}_4$  and  $\text{SO}_4^{2-}$
11. The pH of solution **X** is 1 and that of **Y** is 2. Which statement is correct about the hydrogen ion concentrations in the two solutions?
- A.  $[\text{H}^+]$  in **X** is half that in **Y**.
- B.  $[\text{H}^+]$  in **X** is twice that in **Y**.
- C.  $[\text{H}^+]$  in **X** is one tenth of that in **Y**.
- D.  $[\text{H}^+]$  in **X** is ten times that in **Y**.
12. Which change in  $[\text{H}^+]$  causes the biggest increase in pH?
- A. A change in  $[\text{H}^+(\text{aq})]$  from  $1 \times 10^{-3}$  to  $1 \times 10^{-2} \text{ mol dm}^{-3}$
- B. A change in  $[\text{H}^+(\text{aq})]$  from  $1 \times 10^{-3}$  to  $1 \times 10^{-4} \text{ mol dm}^{-3}$
- C. A change in  $[\text{H}^+(\text{aq})]$  from  $1 \times 10^{-4}$  to  $1 \times 10^{-2} \text{ mol dm}^{-3}$
- D. A change in  $[\text{H}^+(\text{aq})]$  from  $1 \times 10^{-4}$  to  $1 \times 10^{-6} \text{ mol dm}^{-3}$
13. The pH of a solution changes from pH = 1 to pH = 3. What happens to the  $[\text{H}^+]$  during this pH change?
- A. It increases by a factor of 100.
- B. It decreases by a factor of 100.
- C. It increases by a factor of 1000.
- D. It decreases by a factor of 1000.
14. Solutions of hydrochloric acid ( $\text{HCl}(\text{aq})$ ) and ethanoic acid ( $\text{CH}_3\text{COOH}(\text{aq})$ ) of the same concentration reacted completely with 5.0 g of calcium carbonate in separate containers. Which statement is correct?
- A.  $\text{CH}_3\text{COOH}(\text{aq})$  reacted slower because it has a lower pH than  $\text{HCl}(\text{aq})$ .
- B. A smaller volume of  $\text{CO}_2(\text{g})$  was produced with  $\text{CH}_3\text{COOH}(\text{aq})$  than with  $\text{HCl}(\text{aq})$ .
- C. A greater volume of  $\text{CO}_2(\text{g})$  was produced with  $\text{CH}_3\text{COOH}(\text{aq})$  than with  $\text{HCl}(\text{aq})$ .
- D. The same volume of  $\text{CO}_2(\text{g})$  was produced with both  $\text{CH}_3\text{COOH}(\text{aq})$  and  $\text{HCl}(\text{aq})$ .
15. Which acids are strong?
- I.  $\text{HCl}(\text{aq})$
- II.  $\text{HNO}_3(\text{aq})$
- III.  $\text{H}_2\text{SO}_4(\text{aq})$
- A. I and II only
- B. I and III only
- C. II and III only
- D. I, II and III
16. Which species can act as a Lewis acid?
- A.  $\text{BF}_3$
- B.  $\text{OH}^-$
- C.  $\text{H}_2\text{O}$
- D.  $\text{NH}_3$

17. Which methods can distinguish between solutions of a strong monoprotic acid and a weak monoprotic acid of the same concentration?
- Add magnesium to each solution and measure the rate of the formation of gas bubbles.
  - Add aqueous sodium hydroxide to each solution and measure the temperature change.
  - Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.
- A. I and II only  
B. I and III only  
C. II and III only  
D. I, II and III
18. Which methods will distinguish between equimolar solutions of a strong base and a strong acid?
- Add magnesium to each solution and look for the formation of gas bubbles.
  - Add aqueous sodium hydroxide to each solution and measure the temperature change.
  - Use each solution in a circuit with a battery and lamp and see how bright the lamp glows.
- A. I and II only  
B. I and III only  
C. II and III only  
D. I, II and III
19. Which substance, when dissolved in water, to give a  $0.1 \text{ mol dm}^{-3}$  solution, has the highest pH?
- A. HCl  
B. NaCl  
C.  $\text{NH}_3$   
D. NaOH
20. Define the terms *Brønsted-Lowry acid* and *Lewis acid*. For each type of acid, identify one example other than water and write an equation to illustrate the definition.

(Total 5 marks)

21. Propanoic acid is classified as a weak acid.
- (a) State the meaning of the term *weak acid*.
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- .....
- (1)
- (b) State, giving a reason in each case, **two** methods other than measuring pH, that could be used to distinguish between  $0.100 \text{ mol dm}^{-3}$  propanoic acid and  $0.100 \text{ mol dm}^{-3}$  nitric acid.

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(2)

(Total 3 marks)

22. (i) Calcium carbonate is added to separate solutions of hydrochloric acid and ethanoic acid of the same concentration. State **one** similarity and **one** difference in the observations you could make.
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- (2)
- (ii) Write an equation for the reaction between hydrochloric acid and calcium carbonate.

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(2)

- (iii) Determine the volume of  $1.50 \text{ mol dm}^{-3}$  hydrochloric acid that would react with exactly 1.25 g of calcium carbonate.

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(3)

- (iv) Calculate the volume of carbon dioxide, measured at 273 K and  $1.01 \times 10^5 \text{ Pa}$ , which would be produced when 1.25 g of calcium carbonate reacts completely with the hydrochloric acid.

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(2)

(Total 9 marks)

23. Vinegar has a pH of approximately 3 and some detergents have a pH of approximately 8. State and explain which of these has the higher concentration of  $\text{H}^+$  and by what factor.

(Total 1 mark)

24. The pH values of three acidic solutions, X, Y and Z, are shown in the following table:

Solution	Acid	pH
X	$\text{HCl(aq)}$	2
Y	$\text{HCl(aq)}$	4
Z	$\text{CH}_3\text{COOH(aq)}$	4

- (i) Solutions X and Z have the same acid concentration. Explain, by reference to both acids, why they have different pH values.

(2)

- (ii) Deduce by what factor the values of  $[\text{H}^+]$  in solutions X and Y differ.

(1)

(Total 3 marks)

25. Lactic acid  $\text{CH}_3\text{CH(OH)COOH}$  is a weak monoprotic acid

( $\text{p}K_a = 3.85$  and  $K_a = 1.4 \times 10^{-4} \text{ mol dm}^{-3}$ ).

- (i) Write an equation for the reaction of lactic acid with water.

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(1)

- (ii) State the ionization constant expression,  $K_a$ , for lactic acid.

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(1)

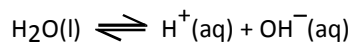
(Total 2 marks)

26. State what is meant by the term *buffer solution*.

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(Total 2 marks)

27. The value of the ionic product constant of water,  $K_W$ , at 60°C is  $5.60 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ , and the dissociation of water takes place as follows:



(a) State the expression for  $K_W$ .

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(1)

(b) Calculate the values of  $[\text{H}^+]$  and pH in water at 60°C.

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(3)

(Total 4 marks)